



# CERTIFICATION TEST REPORT

**Report Number. :** 13179110-E19V2

**Applicant :** APPLE, INC.  
1 APPLE PARK WAY  
CUPERTINO, CA 95014, U.S.A.

**Model :** A2176 (Representative)  
A2398  
A2399/A2400/A2401

**FCC ID :** BCG-E3539A (Representative)  
BCG-E3540A  
BCG-E3541A

**IC :** 579C-E3539A (Representative)  
579C-E3540A  
579C-E3541A

**EUT Description :** SMARTPHONE

**Test Standard(s) :** FCC PART 1 SUBPART I AND PART 2  
SUBPART J  
IC RSS-102 ISSUE 5

**Date Of Issue:**  
OCTOBER 01, 2020

**Prepared by:**  
UL Verification Services Inc.  
47173 Benicia Street  
Fremont, CA 94538, U.S.A.  
TEL: (510) 771-1000  
FAX: (510) 661-0888



NVLAP LAB CODE 200065-0

Revision History

<u>Rev.</u>	<u>Issue Date</u>	<u>Revisions</u>	<u>Revised By</u>
V1	10/1/2020	Initial Review	Mengistu Mekuria

## TABLE OF CONTENTS

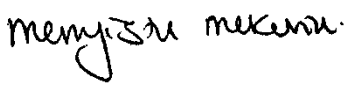
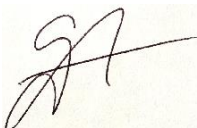
<b>1. ATTESTATION OF TEST RESULTS</b> .....	<b>4</b>
<b>2. TEST METHODOLOGY</b> .....	<b>5</b>
<b>3. REFERENCES</b> .....	<b>5</b>
<b>4. FACILITIES AND ACCREDITATION</b> .....	<b>5</b>
<b>5. EQUIPMENT UNDER TEST</b> .....	<b>6</b>
5.1. <i>DESCRIPTION OF EUT</i> .....	6
5.2. <i>WORST-CASE CONFIGURATION AND MODE</i> .....	6
<b>6. MAXIMUM PERMISSIBLE RF EXPOSURE</b> .....	<b>8</b>
6.1. <i>FCC RULES</i> .....	8
6.2. <i>IC RULES</i> .....	9
6.3. <i>EQUATIONS</i> .....	10
6.4. <i>IC EXEMPTION</i> .....	11
<b>7. RF EXPOSURE RESULTS</b> .....	<b>12</b>

# 1. ATTESTATION OF TEST RESULTS

Applicant Name and Address	APPLE, INC. 1 APPLE PARK WAY CUPERTINO, CA 95014, U.S.A.
Model	A2176 (REPRESENTATIVE), A2398, A2399, A2400, A2401
FCC ID	BCG-E3539A (REPRESENTATIVE) , BCG-E3540A, BCG-E3541A
IC	579C-E3539A (REPRESENTATIVE), 579C-E3540A, 579C-E3541A
EUT Description	SMARTPHONE
Applicable Standards	FCC PART 1 SUBPART I AND PART 2 SUBPART J IC RSS-102 ISSUE 5
Test Results	COMPLIES

UL Verification Services Inc. tested the above equipment in accordance with the requirements set forth in the above standards. All indications of Pass/Fail in this report are opinions expressed by UL Verification Services Inc. based on interpretations and/or observations of test results. Measurement Uncertainties were not taken into account and are published for informational purposes only. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.

**Note:** The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein. This document may not be altered or revised in any way unless done so by UL Verification Services Inc. and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by UL Verification Services Inc. will constitute fraud and shall nullify the document. This report must not be used by the client to claim product certification, approval, or endorsement by NVLAP, NIST, any agency of the Federal Government, or any agency of any government (NIST Handbook 150, Annex A). This report is written to support regulatory compliance of the applicable standards stated above.

Approved & Released By:  	Prepared By:  
Mengistu Mekuria Lead Test Engineer UL Verification Services Inc.	Sintia Andean Laboratory Engineer UL Verification Services Inc.

## 2. TEST METHODOLOGY

All calculations were made in accordance with FCC OET Bulletin 65 Edition 97-01 and IC Safety Code 6.

## 3. REFERENCES

All transmit characteristics used in this evaluations were documented in the UL Verification Services Inc. document 13179110 (WWAN, BT, WiFi reports) and Antenna Gain exhibit

Output power and Duty cycle is excerpted from the RF report. Antenna gain data is excerpted from Antenna Gain exhibit.

## 4. FACILITIES AND ACCREDITATION

The test sites and measurement facilities used to collect data are located at 47173 Benicia Street, Fremont, California, USA.

The above test sites and facilities are covered under FCC Test Firm Registration # 208313. UL Verification Services Inc. is accredited by NVLAP, Laboratory Code 200065-0. The full scope of accreditation can be viewed at [NVLAP Lab Search](#).

## 5. EQUIPMENT UNDER TEST

### 5.1. DESCRIPTION OF EUT

The Apple iPhone is a smartphone with multimedia functions (music, application support, and video), cellular GSM, GPRS, EGPRS, UMTS, LTE, 5G, CDMA, IEEE 802.11a/b/g/n/ac/ax, Bluetooth, Ultra-Wideband, GPS, NFC and WPT. All models support at least one UICC based SIM. The second SIM is either an UICC based p-SIM (physical SIM) or e-SIM (electronic SIM). The device supports a built-in inductive charging transmitter and receiver. The rechargeable battery is not user accessible.

The MPE analysis performed in this report evaluates a unique mobile use case where the handset is placed on a Apple proprietary wireless charger. The cellular, WiFi and Bluetooth transmitters can be active while being charged. The power levels used and reported in this analysis are specific for this use condition only. Simultaneous transmission for these transmitters are analyzed herein without the wireless charger. The simultaneous transmission use condition and permitted configuration together with the charger will be addressed in the applicable wireless charger certification application

### 5.2. WORST-CASE CONFIGURATION AND MODE

The worst-case is when the EUT is transmitting on the highest power allowed for each of the transmit bands, as specified in the RF reports

The table below is used to determine the worst-case co-located simultaneous transmission for evaluation.

Band 4 covered by band 66 since LTE Band 4 has equal or lower output power than LTE band 66.

Band 38 covered by band 41 since LTE Band 38 has equal or lower output power than LTE band 41.

For 5G NR Bands (n2, n5, n12, n25, n41, n66, and n71) having the same operations bandwidth and Power are covered by LTE bands of (Band 2, Band5, Band12, Band 25, Band 41, Band 66, and Band 71).

Simultaneous Transmission	Technology	WLAN 2.4	BT 2.4	WLAN 5G
Technology	Output Power (dBm)	22.5	20.0	21.5
GSM 850	33.50	*	*	*
GSM 1900	32.00	**	**	**
WCDMA Band II	25.70	**	**	**
WCDMA Band IV	25.70	**	**	**
WCDMA Band V	25.70	**	**	**
CDMA/EVDO BC0	25.70	**	**	**
CDMA/EVDO BC1	25.70	**	**	**
CDMA/EVDO BC10	25.70	**	**	**
LTE Band 2	25.70	**	**	**
LTE Band 5	25.70	**	**	**
5G NR Band n5	25.70	**	**	**
LTE Band 7	25.70	**	**	**
LTE Band 12	25.70	**	**	**
5G NR Band n12	25.70	**	**	**
LTE Band 13	25.70	**	**	**
LTE Band 14	25.70	**	**	**
LTE Band 17	25.70	**	**	**
LTE Band 25	25.70	**	**	**
LTE Band 26	25.70	**	**	**
LTE Band 30	25.70	**	**	**
LTE Band 41	27.70	**	**	**
5G NR Band n41	27.50	**	**	**
LTE Band 48	24.60	**	**	**
LTE Band 66	25.70	**	**	**
LTE Band 71	25.70	**	**	**
5G NR Band n77	25.70	**	**	**
5G NR Band n78	27.50	**	**	**

Note: \* Worst Case for the Co-located MPE Calculation based on the output powers.

\*\* Not the worst case

Band 38 and 5G NR Band n78 used for Canada only.  
 CDMA BC10, LTE B26, Band 48 and 5G NR Band n77 used for US only.

GSM 850 was used for simultaneous transmission evaluation because it does provide the lowest margin of power density to the FCC limit.

## 6. MAXIMUM PERMISSIBLE RF EXPOSURE

### 6.1. FCC RULES

§1.1310 The criteria listed in Table 1 shall be used to evaluate the environmental impact of human exposure to radio-frequency (RF) radiation as specified in §1.1307(b), except in the case of portable devices which shall be evaluated according to the provisions of §2.1093 of this chapter.

**TABLE 1—LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)**

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm <sup>2</sup> )	Averaging time (minutes)
<b>(A) Limits for Occupational/Controlled Exposure</b>				
0.3-3.0	614	1.63	*100	6
3.0-30	1842/f	4.89/f	*900/f <sup>2</sup>	6
30-300	61.4	0.163	1.0	6
300-1,500			f/300	6
1,500-100,000			5	6
<b>(B) Limits for General Population/Uncontrolled Exposure</b>				
0.3-1.34	614	1.63	*100	30
1.34-30	824/f	2.19/f	*180/f <sup>2</sup>	30
30-300	27.5	0.073	0.2	30
300-1,500			f/1500	30
1,500-100,000			1.0	30

f = frequency in MHz

\* = Plane-wave equivalent power density

#### **Notes:**

- (1) Occupational/controlled exposure limits apply in situations in which persons are exposed as a consequence of their employment provided those persons are fully aware of the potential for exposure and can exercise control over their exposure. Limits for occupational/controlled exposure also apply in situations when a person is transient through a location where occupational/controlled limits apply provided he or she is made aware of the potential for exposure.
- (2) General population/uncontrolled exposure limits apply in situations in which the general public may be exposed, or in which persons who are exposed as a consequence of their employment may not be fully aware of the potential for exposure or cannot exercise control over their exposure



## 6.2. IC RULES

IC Safety Code 6 (2015), Section 2.2.2: To ensure compliance with the basic restrictions outlined in Section 2.1, at frequencies between 10 MHz and 300 GHz, the reference levels for electric- and magnetic-field strength and power density must be complied with.

**TABLE 2:** Reference Levels for Electric Field Strength, Magnetic Field Strength and Power Density in Uncontrolled Environments

<b>Table 2: RF Field Strength Limits for Devices Used by the General Public (Uncontrolled Environment)</b>				
<b>Note:</b> $f$ is frequency in MHz.				
Frequency Range (MHz)	Electric Field (V/m rms)	Magnetic Field (A/m rms)	Power Density (W/m <sup>2</sup> )	Reference Period (minutes)
10-20	27.46	0.0728	-2	6
20-48	$58.07/f^{0.25}$	$0.1540/f^{0.25}$	$8.944/f^{0.5}$	6
48-300	22.06	0.05852	1.291	6
300-6000	$3.142 f^{0.3417}$	$0.008335 f^{0.3417}$	$0.02619 f^{0.6834}$	6
6000-15000	61.4	0.163	10	6
15000-150000	61.4	0.163	10	$616000/f^{1.2}$
150000-300000	$0.158 f^{0.5}$	$4.21 \times 10^{-4} f^{0.5}$	$6.67 \times 10^{-5} f$	$616000/f^{1.2}$

**TABLE 3:** Reference Levels for Electric Field Strength, Magnetic Field Strength and Power Density in Controlled Environments

<b>Table 3: RF Field Strength Limits for Controlled Use Devices (Controlled Environment)</b>				
<b>Note:</b> $f$ is frequency in MHz.				
Frequency Range (MHz)	Electric Field (V/m rms)	Magnetic Field (A/m rms)	Power Density (W/m <sup>2</sup> )	Reference Period (minutes)
10-20	61.4	0.163	-10	6
20-48	$129.8/f^{0.25}$	$0.3444/f^{0.25}$	$44.72/f^{0.5}$	6
48-100	49.33	0.1309	6.455	6
100-6000	$15.60 f^{0.25}$	$0.04138 f^{0.25}$	$0.6455 f^{0.5}$	6
6000-15000	137	0.364	50	6
15000-150000	137	0.364	50	$616000/f^{1.2}$
150000-300000	$0.354 f^{0.5}$	$9.40 \times 10^{-4} f^{0.5}$	$3.33 \times 10^{-4} f$	616000

### **6.3. EQUATIONS**

#### **POWER DENSITY**

Power density is given by:

$$S = \text{EIRP} / (4 * \text{Pi} * \text{D}^2)$$

Where

S = Power density in mW/cm<sup>2</sup>

EIRP = Equivalent Isotropic Radiated Power in mW

D = Separation distance in cm

Power density in units of mW/cm<sup>2</sup> is converted to units of W/m<sup>2</sup> by multiplying by 10.

#### **DISTANCE**

Distance is given by:

$$D = \text{SQRT} (\text{EIRP} / (4 * \text{Pi} * S))$$

Where

D = Separation distance in cm

EIRP = Equivalent Isotropic Radiated Power in mW

S = Power density in mW/cm<sup>2</sup>

#### **SOURCE-BASED DUTY CYCLE**

Where applicable (for example, multi-slot cell phone applications) a duty cycle factor may be applied.

$$\text{Source-based time-averaged EIRP} = (\text{DC} / 100) * \text{EIRP}$$

Where

DC = Duty Cycle in %, as applicable

EIRP = Equivalent Isotropic Radiated Power in W

## **MIMO AND COLOCATED TRANSMITTERS**

For multiple colocated transmitters operating simultaneously in frequency bands where different limits apply:

The Power Density at the specified separation distance is calculated for each transmitter chain or transmitter.

The fraction of the exposure limit is calculated for each chain or transmitter as  
(Power Density of chain or transmitter) / (Limit applicable to that chain or transmitter).

The fractions are summed.

Compliance is established if the sum of the fractions is less than or equal to one.

## **6.4. IC EXEMPTION**

### **INDUSTRY CANADA EXEMPTION**

RSS-102 Clause 2.5.2 RF exposure evaluation is required if the separation distance between the user and the device's radiating element is greater than 20 cm, except when the device operates as follows:

- at or above 300 MHz and below 6 GHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than  $1.31 \times 10^{-2} f^{0.6834}$  W (adjusted for tune-up tolerance), where  $f$  is in MHz;

## 7. RF EXPOSURE RESULTS

In the table(s) below, Power and Gain are entered in units of dBm and dBi respectively and conversions to linear forms are used for the calculations of power density at a separation distance of 20cm.

Band	Mode	Frequency (MHz)	Average Power (dBm)	Antenna Gain (dBi)	Duty Cycle %	EIRP (average) mW	Separation Distance (cm)	FCC Power Density (mW/cm <sup>2</sup> )	FCC Limit (mW/cm <sup>2</sup> )	FCC Limit (%)	RSS-102 Power Density (W/m <sup>2</sup> )	RSS-102 Limit (W/m <sup>2</sup> )	RSS 102 Limit (%)
850 MHz	GSM	836	33.50	-3.6	50%	489	20	0.097	0.56	17.4%	0.97	2.60	37.4%
1900 MHz	GSM	1880	32.00	-0.3	50%	740	20	0.147	1.00	14.7%	1.47	4.53	32.5%
Band II	WCDMA	1880	25.70	-0.3	100%	347	20	0.069	1.00	6.9%	0.69	4.53	15.2%
Band IV	WCDMA	1730	25.70	0.1	100%	380	20	0.076	1.00	7.6%	0.76	4.28	17.7%
Band V	WCDMA	836	25.70	-3.6	100%	162	20	0.032	0.56	5.8%	0.32	2.60	12.4%
BC0	CDMA/EVDO	836	25.70	-3.6	100%	162	20	0.032	0.56	5.8%	0.32	2.60	12.4%
BC1	CDMA/EVDO	1880	25.70	-0.3	100%	347	20	0.069	1.00	6.9%	0.69	4.53	15.2%
BC10	CDMA/EVDO	820	25.70	-3.6	100%	162	20	0.032	0.55	5.9%			
Band 2	LTE	1880	25.70	-0.3	100%	347	20	0.069	1.00	6.9%	0.69	4.53	15.2%
Band 5	LTE	836	25.70	-3.6	100%	162	20	0.032	0.56	5.8%	0.32	2.60	12.4%
n5	5G NR	836	25.70	-3.6	100%	162	20	0.032	0.56	5.8%	0.32	2.60	12.4%
Band 7	LTE	2535	25.70	-0.7	100%	316	20	0.063	1.00	6.3%	0.63	5.55	11.3%
Band 12	LTE	707	25.70	-6.2	100%	89	20	0.018	0.47	3.8%	0.18	2.32	7.6%
n12	5G NR	707	25.70	-6.2	100%	89	20	0.018	0.47	3.8%	0.18	2.32	7.6%
Band 13	LTE	782	25.70	-5.2	100%	112	20	0.022	0.52	4.3%	0.22	2.49	9.0%
Band 14	LTE	793	25.70	-5.2	100%	112	20	0.022	0.53	4.2%	0.22	2.51	8.9%
Band 17	LTE	710	25.70	-6.2	100%	89	20	0.018	0.47	3.7%	0.18	2.33	7.6%
Band 25	LTE	1880	25.00	-0.3	100%	295	20	0.059	1.00	5.9%	0.59	4.53	13.0%
Band 26	LTE	820	25.70	-3.6	100%	162	20	0.032	0.55	5.9%			
Band 30	LTE	2310	25.70	-1.3	100%	275	20	0.055	1.00	5.5%	0.55	5.21	10.5%
Band 41	LTE	2600	27.70	1.3	100%	794	20	0.158	1.00	15.8%	1.58	5.65	28.0%
n41	5G NR	2600	26.70	1.3	100%	631	20	0.126	1.00	12.6%	1.26	5.65	22.2%
Band 48	LTE	3600	24.70	0.5	100%	331	20	0.066	1.00	6.6%			
Band 66	LTE	1730	25.70	0.1	100%	380	20	0.076	1.00	7.6%	0.76	4.28	17.7%
Band 71	LTE	680	25.70	-6.9	100%	76	20	0.015	0.45	3.3%	0.15	2.26	6.7%
n77	5G NR	3830	25.70	0.5	100%	417	20	0.083	1.00	8.3%			
n78	5G NR	3830	26.70	0.5	100%	525	20				1.04	7.36	14.2%
Bluetooth ANT 3		2440	20.00	-0.6	100%	87	20	0.017	1.00	1.7%	0.17	5.41	3.2%
Bluetooth ANT 4		2440	20.00	-2.3	100%	59	20	0.012	1.00	1.2%	0.12	5.41	2.2%
2.4 GHz WLAN ANT 3		2440	22.50	-0.6	100%	155	20	0.031	1.00	3.1%	0.31	5.41	5.7%
2.4 GHz WLAN ANT 4		2440	21.00	-2.3	100%	74	20	0.015	1.00	1.5%	0.15	5.41	2.7%
5 GHz WLAN ANT 5		5200	21.50	-2.8	100%	74	20	0.015	1.00	1.5%	0.15	9.07	1.6%
5 GHz WLAN ANT 6		5200	19.75	-0.3	100%	88	20	0.018	1.00	1.8%	0.18	9.07	1.9%

Based on the Power density calculations, all values meet the IC limits specified in section 6.4 and FCC limits.

**Notes:**

- 1) For MPE KDB 447498 requires the calculations to use the maximum rated power; that power should be declared by the manufacturer, and should not be lower than the measured power. Powers used are the maximum rated powers as declared by the manufacturer.
- 2) The output power in the tables above is the maximum power per chain among various channels and various modes within the specific band.
- 3) The antenna gain in the tables above is the maximum antenna gain among various channels within the specified band.

To evaluate the RF exposure for simultaneous transmissions between cellular and WiF/Bluetooth, and, including MIMO operations for Bluetooth and WiFi, the ratios of power density to limit for the worst case cellular transmitter and the applicable WiFi or Bluetooth transmitters are summed. Provided the total is below a ratio of 1.0 (100%) the Device complies with the RF exposure limits at a distance of 20cm.

The simultaneous conditions to evaluate are Celular (WWAN) operating simultaneously with 2.4 GHz Wi-Fi MIMO and with Celular (WWAN) operating simultaneously with 5 GHz Wi-Fi MIMO and Bluetooth MIMO. Bluetooth and 2.4 GHz WiFi cannot operate simultaneously and 2.4 GHz and 5 GHz WiFi cannot operate simultaneously.

**WWAN + 2.4 GHz WiFi (MIMO)**

Worst case WWAN: 17.4% of FCC limit, 37.4% of ISED limit  
2.4 GHz WiFi Ant 3: 3.1% of FCC limit, 5.7% of ISED limit  
2.4 GHz WiFi Ant 4: 1.5% of FCC limit, 2.7 % of ISED limit

Total combined ratio is 22.0% of the FCC limit and 45.8% of the ISED limit.

**WWAN + Bluetooth + 5 GHz WiFi (MIMO)**

Worst case WWAN: 17.4% of FCC limit, 37.4% of ISED limit  
Bluetooth Ant 3: 1.7% of FCC limit, 3.2% of ISED limit  
Bluetooth Ant 4: 1.2 % of FCC limit, 2.2% of ISED limit  
5 GHz WiFi Ant 5: 1.5% of FCC limit, 1.6% of ISED limit  
5 GHz WiFi Ant 6: 1.8% of FCC limit, 1.9% of ISED limit

Total combined ratio is 23.6% of the FCC limit and 46.3% of the ISED limit.

All combined ratios are below 100% and .therefore the simultaneous transmission conditions comply with both FCC and RSS-102 requirements.

**END OF REPORT**